

SPAD Detector Package for Space Born Applications

Ivan Prochazka, Karel Hamal, Josef Blazej, Bruno Sopko

Czech Technical University in Prague
Brehova 7, 115 19 Prague, Czech Republic, fax +420 221912252, prochazk@mbox.cesnet.cz

The SPAD detector package for the space born applications is under development with the envision of several space missions related to time transfer by laser light, one way laser ranging and laser transponder. The requirements on detector package are rather different from the ground based laser ranging systems [1]. Recently, the most challenging task is the development of the solid state detector package capable of non gated operation. The existing detector configurations do not permit non gated operation due to the excess dark count rate of the detector, which is caused by strong after pulsing effect. The after pulsing effect is strongly influenced by the quenching circuit. The longer it takes to quench the avalanche after a photon detection, the stronger is the after effect. The conventional active quenching circuits have a loop delay in the range 20-30 nanoseconds.

We have developed a new active quenching and gating circuit with the loop delay shorter than 3 nanoseconds. It enables to operate the K14 series SPAD detectors in the non gated mode with the acceptable dark count rates and timing resolution, as well. The circuit permits to operate the detector 0.1 to 1.1 Volt above its break voltage. Using the chips with 40 um in diameter, the dark count rates below 15 kHz and a timing resolution of 30 picoseconds have been obtained at a room temperature and non gated operation. The detection chip has been biased 1.0 Volt above its break voltage. The optional gating permits to gate on/off the detector extremely fast. The risetime of the sensitivity from 10^9 photons to a single photon level is below 80 psec, the total rise and overshoot times are below 140 psec.

The compact and rugged solid state photon counting detector package capable to operate in both non gated and gated modes has been developed. The dark count rate is 10 Hz to 10 kHz within the temperature range of -60 to +20 Celsius, the timing resolution is 30 psec. The detector mass is 30 grams, its power consumption is below 400 mWatts. The detection chip has been space qualified for previous deep space missions [2].

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References

1. I.Procházka, K.Hamal, G.Kirchner, B.Sopko, *Photodiode for Subcentimeter Satellite Laser Ranging Operating at Room Temperature and Single Photon Level*, Technical Digest Series, Vol.7, Optical Society of America, Washington DC, 1990, pp.138
2. S.Pershin, V.Linkin, V.Makarov, I.Procházka, K.Hamal, *Spaceborn Altimeter Based on a Semiconductor Laser Transmitter and a Single Photon Dide Receiver*, Technical Digest Series, Vol.10, Optical Society of America, Washington DC, 1991, pp.520

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I. Prochazka, K.Hamal
J.Blazej, B.Sopko

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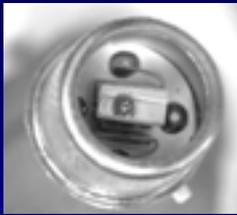
Czech Technical University in Prague
Prague, Czech Republic

Goals:

- To develop the photon counting detector package tailored for space applications
- requirements
 - ◆ solid state
 - ◆ low mass and low power
 - ◆ picosecond resolution & stability
 - ◆ CW operation (not gated)

Philosophy

- use the SPAD chips available operated in active quenching mode
- reduce the after-pulsing effects by shortening the circuit loop delay
- => develop a new quenching circuit with the loop delay $\ll 20$ nsec



100um K14 SPAD TE1 cooling

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CW SPAD circuit

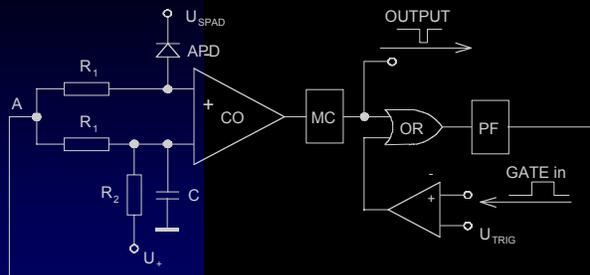
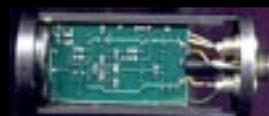


Figure 1: Active quenching circuit for the laser transponder

CO comparator
PF pulse forming
MC monostable
OR gate

PROTOTYPE BOARD

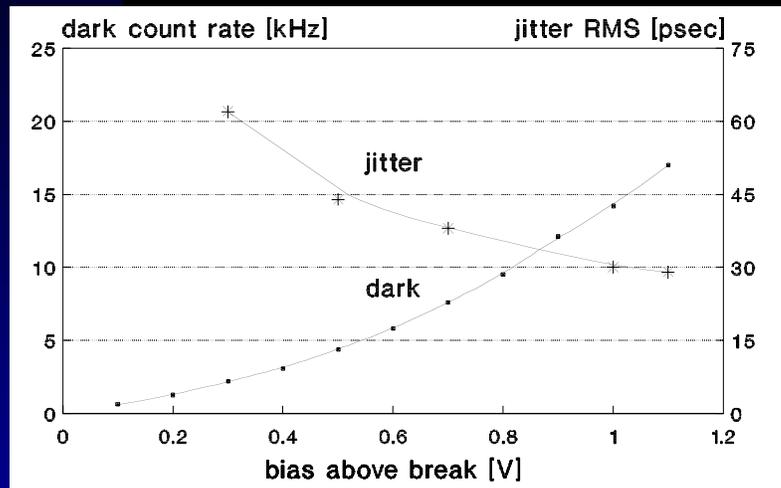


ECL 100 k logic
32x40 mm, SMD
loop delay 2.6ns
 $V_{ab} < 1.2$ Volt

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CW SPAD operation

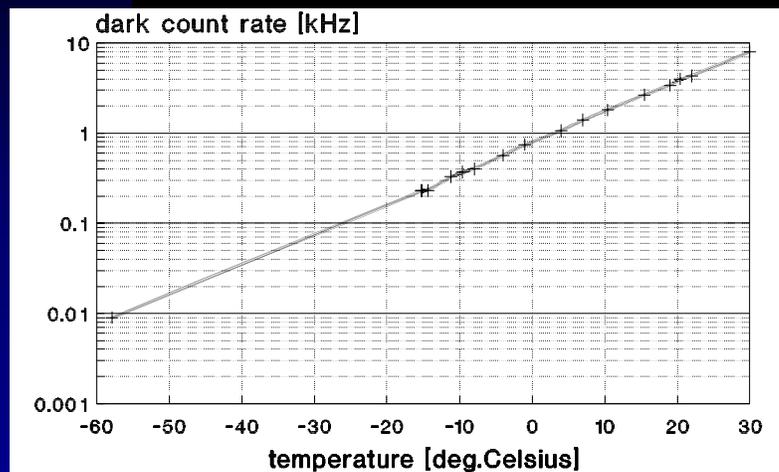
Dark count and timing resolution versus bias
Active area diameter 40 μm , +25 C



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CW SPAD operation

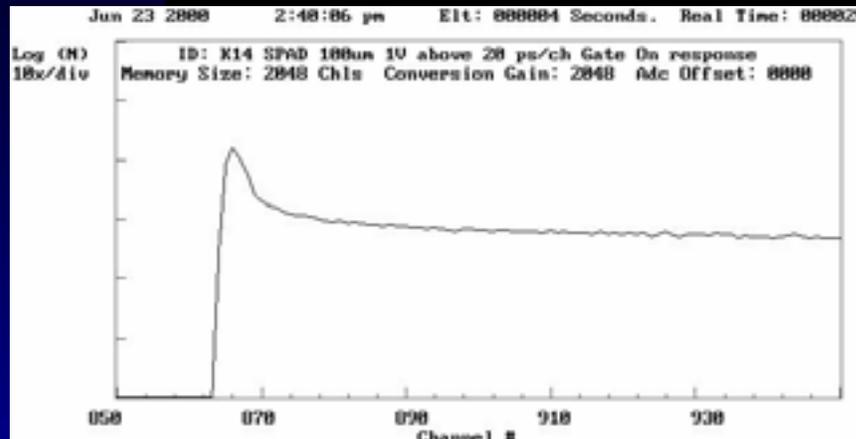
Dark count rate versus temperature
Active area diameter 40 μm , 07 V above break



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CW SPAD optional gating

Gate ON time response, 100 um chip, 1 V above
risetime < 80 psec, risetime+overshot < 140 psec



20 psec/channel, 2 nsec / screen

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Conclusion

- The active quenching and gating circuit for the **CW operation** of Si SPAD 40 um has been designed and tested
- the SPAD dark count rate is 10 Hz to 10kHz within the temperature range -60 to +25 C
- the timing resolution is 30 psec RMS
- suitable for space : radiation resistant
Mass < 30 grams, Power < 400 mW



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